WHAT IS CLAIMED IS:

1. A method for removing the protective coatings from components of gas turbine engines, comprising the steps of:

removing any residual dirt, grit or oxide materials on the coated surfaces of said components using an ultrasonic aqueous bath;

exposing substantially the entire inside and outside coated surfaces of individual components to a stripping agent capable of reacting with the aluminum component of said thermal insulating coatings but substantially non-reactive with the underlying metal substrate of said components;

circulating said stripping agent in a closed loop to continuously expose the inside and outside surfaces of individual components and thereby remove said protective coatings through a chemical reaction with said stripping agent;

removing said components from said stripping agent; and

rinsing said components in an aqueous bath to remove any residual stripping agent.

2. The method according to claim 1, further comprising the step of removing any residual coating material using a high pressure air stream before said step of rinsing said components in an aqueous bath.

3. The method according to claim 1, wherein said stripping agent comprises an aqueous solution of fluorosilicic acid.

4. The method according to claim 1, wherein said stripping agent comprises an aqueous solution of hydrochloric acid.

5. The method according to claim 1, wherein said stripping agent comprises an aqueous solution of phosphoric acid.

6. The method according to claim 3, wherein said aqueous solution of fluorosilicic acid comprises about 23-25 weight percent H_2SiF_6 in water.

7. The method according to claim 4, wherein said aqueous solution of hydrochloric acid comprises about 37-39 percent by weight HCl in water.

8. The method according to claim 5, wherein said aqueous solution of phosphoric acid comprises about 85 percent by weight phosphoric acid in water.

9. The method according to claim 1, wherein said stripping agent comprises an aqueous composition having the general formula H_xAF_6, wherein A can be Si, Ge, Ti, Zr, Al and Ga, and X is 1-6.

10. The method according to claim 9, wherein said stripping agent also includes an additional acid, such as phosphoric acid, nitric acid, sulfuric acid, hydrochloric acid, hydrofluoric acid, and mixtures thereof.

11. The method according to claim 1, wherein the step of circulating said stripping agent takes place continuously over a period of about 12 hours.

12. The method according to claim 1, wherein said step of circulating said stripping agent continuously exposes the exterior and interior portions of said turbine engine component to selected amounts of said stripping agent under substantially uniform conditions.

13. An apparatus for removing oxidation-resistant coatings on the interior or exterior surfaces of the components of gas turbine engines, comprising

a holding tank sized to receive one or more gas turbine engine components and a volume of stripping agent;

one or more pumps capable of continuously circulating a portion of said stripping agent to said components in a closed loop inside said holding tank;

fluid distribution piping capable of transporting said stripping agent under moderate pressure within said closed loop;

manifold piping sized to distribute substantially equal portions of said stripping agent to one or more individual turbine engine components;

a mounting structure disposed inside said holding tank for mounting one or more of said turbine engine components and distributing said stripping agent to individual turbine engine components.

14. The apparatus according to claim 13, wherein said mounting structure includes a cage divided into separate discreet compartments capable of receiving and securing individual gas turbine components.

15. The apparatus according to claim 13, further comprising one or more fluid lines extending from said manifold piping to individual stripping compartments in said cage and coupled to said mounting structure.

16. The apparatus according to claim 13, wherein all of the components exposed to said stripping agent are coated with or comprise polypropylene.

17. The apparatus according to claim 13, wherein said mounting structure includes a flat mounting plate secured to a plenum plate having an interior configuration capable of distributing portions of said stripping agent to individual turbine engine components.

Claims

[c1] 1. A chemical stripping method for selectively removing a diffusion aluminide coating from a substrate, comprising the step of contacting the coating with an aqueous composition comprising at least one acid having the formula $H_x ZrF_6$, or precursors to said acid, wherein x is 1-6.

[c2] 2. The method as recited in claim 1, wherein x is 1-3.

[c3] 3. The method as recited in claim 1, wherein the acid is present at a concentration in the range of about 0.05 M to about 5 M.

[c4] 4. The method as recited in claim 3, wherein the acid is present at a concentration in the range of about 0.5 M to about 3.5 M.

[c5] 5. The method as recited in claim 1, wherein the precursor is a salt of the acid.

[c6] 6. The method as recited in claim 1, wherein the aqueous composition comprises the compound $H_2 ZrF_6$.

[c7] 7. The method as recited in claim 6, wherein the $H_2 ZrF_6$ compound is formed in situ within the aqueous composition, by the dissociation of a corresponding salt of the compound; or by the reaction of a zirconium-containing compound with a fluorine-containing compound.

[c8] 8. The method as recited in claim 7, wherein the zirconium-containing compound is ZrO_2, and the fluorine-containing compound is HF.

[c9] 9. The method of claim 1, wherein the substrate is immersed in a bath of the aqueous composition.

[c10] 10. The method of claim 9, wherein the aqueous composition is maintained at a temperature in the range of room temperature to about 100 ° C.

[c11] 11. The method of claim 10, wherein the aqueous composition is maintained at a temperature in the range of about 30C to about 85C.

[c12] 12. The method of claim 10, wherein the substrate is immersed in the aqueous composition for a time period in the range of about 1 minute to about 10 hours.

[c13] 13. The method as recited in claim 1, wherein the aqueous composition further comprises at least one additive selected from the group consisting of inhibitors, dispersants, surfactants, chelating agents, wetting agents, deflocculants, stabilizers, anti-settling agents, and anti-foam agents.

[c14] 14. The method as recited in claim 1, wherein the diffusion aluminide coating comprises a diffusion sublayer over the substrate, and an additive sublayer over the diffusion sublayer.

[c15] 15. The method as recited in claim 14, wherein the coating being removed is the additive sublayer, while the diffusion sublayer is substantially unaffected.

[c16] 16. The method as recited in claim 1, wherein the diffusion aluminide material is a noble metal-aluminide, and the noble metal is selected from the group consisting of platinum, palladium, and mixtures thereof.

[c17] 17. The method as recited in claim 1, wherein the substrate comprises at least one element selected from the group consisting of iron, cobalt, nickel, aluminum, chromium, titanium, and mixtures that include any of the foregoing metallics.

[c18] 18. The method as recited in claim 17, wherein the substrate comprises a superalloy.

[c19] 19. The method as recited in claim 18, wherein the superalloy is nickel-based or cobalt-based.

[c20] 20. The method as recited in claim 19, wherein the superalloy is a component of a turbine engine.

[c21] 21. The method as recited in claim 20, wherein the component comprises an airfoil.

[c22] 22. The method as recited in claim 1, further comprising the step of removing coating residue after treatment in the aqueous composition.

[c23] 23. The method as recited in claim 22, wherein the coating residue is removed by a technique selected from the group consisting of abrasion, tumbling, laser ablation, and ultrasonic agitation.

[c24] 24. The method as recited in claim 23, wherein the abrasion is carried out by a grit-blasting technique.

[c25] 25. A chemical stripping method for selectively removing a diffusion platinum-aluminide coating from a superalloy substrate, comprising the step of treating the substrate with an aqueous composition comprising at least one acid having the formula $H_x ZrF_6$; wherein x is 1-6.

[c26] 26. The method of claim 25, wherein the substrate is treated with the aqueous composition in a bath, for a period of time sufficient to remove an overlying additive sublayer of the coating, while not substantially removing an underlying diffusion sublayer of the coating.

[c27] 27. The method of claim 26, wherein the substrate is a turbine component or combustor component of a gas turbine engine.

[c28] 28. A method for replacing a worn or damaged diffusion aluminide coating applied over a substrate, comprising the following steps:
(i) chemically removing the worn or damaged coating by contacting the substrate with an aqueous composition, wherein the aqueous composition comprises an acid having the formula $H_x ZrF_6$, where x is 1-6, or precursors to said acid; and then
(ii) applying a new coating over the substrate.

[c29] 29. The method of claim 28, wherein the diffusion aluminide coating comprises a diffusion sublayer which lies over the substrate, and an additive sublayer which lies over the diffusion sublayer.

[c30] 30. The method of claim 29, wherein the additive sublayer is removed, while the diffusion sublayer is substantially unaffected.

[c31] 31. The method of claim 28, wherein the new coating is a diffusion-aluminide coating or an overlay coating.

[c32] 32. The method of claim 31, wherein the overlay coating comprises a composition of the formula MCrAl(X), where M is an element selected from the group consisting of Ni, Co, Fe, and combinations thereof; and X is an element selected from the group consisting of Y, Ta, Si, Hf, Ti, Zr, B, C, and combinations thereof.

[c33] 33. An aqueous stripping composition for selectively removing a diffusion aluminide coating from a substrate, comprising an acid having the formula $H_x ZrF_6$, where x is 1-6, or precursors to said acid, wherein the acid is present in the composition at a concentration in the range of about 0.5 M to about 3.5 M.

[c34] 34. The stripping composition of claim 33, further comprising at least one additive selected from the group consisting of inhibitors, dispersants, surfactants, chelating agents, wetting agents, deflocculants, stabilizers, anti-settling agents, and anti-foam agents.

[c35] 35. The stripping composition of claim 33, in which a gas turbine engine component is immersed.

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A method for selectively removing at least one coating from the surface of a substrate, comprising the step of contacting the coating with an aqueous composition which comprises at least one of an acid having the formula H_xAF_6, and precursors to said acid, wherein A is selected from the group consisting of Si, Ge, Ti, Zr, Al, and Ga; wherein x is 1-6; and wherein contacting said coating further comprises contacting a coating comprising at least one of

a. ~~a diffusion coating comprising~~ an aluminide material, and

b. ~~an overlay coating comprising~~ MCrAl(X), where M is an element selected from the group consisting of Ni, Co, Fe, and combinations thereof, and X is an element selected from the group consisting of Y, Ta, Si, Hf, Ti, Zr, B, C, and combinations thereof;

said coating comprising at least one of a diffusion coating and an overlay coating.

2. (Original) The method of claim 1, wherein x is 1-3.

3. (Original) The method of claim 1, wherein the acid is present at a level in the range of about 0.05 M to about 5 M.

4. (Original) The method of claim 3, wherein the acid is present at a level in the range of about 0.2 M to about 3.5 M.

5. (Original) The method of claim 1, wherein the precursor is a salt of the acid.

6. (Original) The method of claim 1, wherein the aqueous composition comprises the compound H2SiF6 or H2ZrF6.

7. (Original) The method of claim 6, wherein the H2SiF6 compound is formed in situ within the aqueous composition, by the dissociation of a corresponding salt of the compound; or by the reaction of a silicon-containing compound with a fluorine-containing

compound.

8. (Original) The method of claim 7, wherein the silicon-containing compound is SiO2, and the fluorine-containing compound is HF.

9. (Original) The method of claim 1, wherein the aqueous composition further comprises at least one additional acid or precursor thereof.

10. (Original) The method of claim 9, wherein the additional acid has a pH of less than about 7 in pure water.

11. (Original) The method of claim 10, wherein the additional acid has a pH of less than about 3.5 in pure water.

12. (Original) The method of claim 9, wherein the additional acid is a mineral acid.

13. (Original) The method of claim 9, wherein the additional acid is selected from the group consisting of phosphoric acid, nitric acid, sulfuric acid, hydrochloric acid, hydrofluoric acid, hydrobromic acid, hydriodic acid, acetic acid, perchloric acid, phosphorous acid, phosphinic acid, alkyl sulfonic acids, and mixtures of any of the foregoing.

14. (Original) The method of claim 9, wherein the additional acid is present in the composition at a level in the range of about 0.1 M to about 20 M.

15. (Original) The method of claim 14, wherein the additional acid is phosphoric acid.

16. (Original) The method of claim 15, wherein the phosphoric acid is present at a level in the range of about 0.5 M to about 5 M.

17. (Original) The method of claim 1, wherein the substrate is immersed in a bath of the aqueous composition.

18. (Original) The method of claim 17, wherein the bath is maintained at a temperature in the range of about room temperature to about 100*C, while the substrate is immersed therein.

19. (Original) The method of claim 18, wherein the temperature is in the range of about 45°C to about 90°C.

20. (Original) The method of claim 18, wherein the immersion time is in the range of about 10 minutes to about 72 hours.

21. (Original) The method of claim 20, wherein the immersion time is in the range of about 60 minutes to about 20 hours.

22. (Original) The method of claim 17, wherein the bath further comprises at least one additive selected from the group consisting of inhibitors, dispersants, surfactants, chelating agents, wetting agents, deflocculants, stabilizers, anti-settling agents, and anti-foam agents.

23. (Cancelled)

24. (Cancelled)

25. (Original) The method of claim ~~24~~ 1, wherein the aluminide material is selected from the group consisting of aluminide, noble metal-aluminide, nickel-aluminide, noble metal-nickel-aluminide, and mixtures thereof.

26. (Cancelled)

27. (Previously Presented) The method of claim 1, wherein the substrate is selected from the group consisting of a metallic material and a polymeric material.

28. (Original) The method of claim 27, wherein the polymeric material is selected from the group consisting of polyolefins, polytetrafluroethylenes, epoxy resins, polystyrenes, polyphenylene ethers; mixtures comprising one of the foregoing; and copolymers comprising one of the foregoing.

29. (Original) The method of claim 27, wherein the metallic material comprises at least one element selected from the group consisting of iron, cobalt, nickel, aluminum, chromium, titanium, and mixtures which include any of the foregoing.

30. (Original) The method of claim 29, wherein the metallic material comprises a superalloy.

31. (Original) The method of claim 30, wherein the superalloy is nickel-based or cobalt-based.

32. (Original) The method of claim 30, wherein the superalloy is a component of a turbine engine.

33. (Original) The method of claim 32, wherein the component comprises an airfoil.

34. (Previously Presented) A method for selectively removing at least one coating material from the surface of a metallic substrate, comprising the step of contacting the coating with an aqueous composition which comprises at least one of an acid having the formula H_xAF_6, and precursors to said acid, wherein A is selected from the group consisting of Si, Ti, and Zr; wherein x is 1-3; and wherein contacting said coating further comprises contacting a coating comprising materials selected from the group consisting of aluminides and MCrAlY materials, wherein M is an element selected from the group consisting of Ni, Co, Fe, and combinations thereof.

35. (Original) The method of claim 34, wherein the acid is present at a level in the range of about 0.05 M to about 5 M.

36. (Original) The method of claim 34, wherein the aqueous composition further comprises at least one additional acid or precursor thereof, selected from the group consisting of phosphoric acid, nitric acid, sulfuric acid, hydrochloric acid, hydrofluoric acid, and mixtures thereof.

37. (Original) The method of claim 36, wherein the additional acid is present in the composition at a level in the range of about 0.1 M to about 20 M.

38. (Cancelled)

39. (Original) The method of claim 34, wherein the coating material comprises an MCrAlY layer which is diffusion-aluminided.

40. (Original) The method of claim 34, wherein the metallic substrate comprises a nickel-base or cobalt-base superalloy.

41. (Original) The method of claim 40, wherein the metallic substrate is a turbine engine airfoil.

42. (Previously Presented) An aqueous composition for selectively removing a coating from the surface of a substrate, comprising at least one of an acid having the formula H_xAF_6, and precursors to said acid, wherein A is selected from the group consisting of Si, Ge, Ti, Zr, Al, and Ga; and x is 1-6,

said acid being present in the composition at a level in the range of about 0.05 M to about 5 M.

43. (Original) The composition of claim 42, further including at least one additional acid or precursor thereof.

44. (Original) The composition of claim 43, wherein the additional acid has a pH of less than about 7 in pure water.

45. (Original) The composition of claim 44, wherein the additional acid has a pH of less than about 3.5 in pure water.

46. (Original) The composition of claim 43, wherein the additional acid is a mineral acid.

47. (Original) The composition of claim 43, wherein the additional acid is selected from the group consisting of phosphoric acid, nitric acid, sulfuric acid, hydrochloric acid, hydrofluoric acid, hydrobromic acid, hydriodic acid, acetic acid, perchloric acid, phosphorous acid, phosphinic acid, alkyl sulfonic acids, and mixtures of any of the foregoing.

48. (Original) The composition of claim 43, wherein the additional acid is present in the composition at a level in the range of about 0.1 M to about 20 M.